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INTERFACE REQUIREMENTS DOCUMENT (IRD)

FOR THE

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE SERIES R (GOES-R) SYSTEM

SPACE SEGMENT (SS)
TO
LOW RATE INFORMATION TRANSMISSION (LRIT) SERVICE

Document No.
417-SeriesR-IRD-0003

March 22, 2005

GOES-R PROJECT OFFICE
NASA GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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SPACE SEGMENT (SS) TO LOW RATE INFORMATION TRANSMISSION (LRIT) SERVICE

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1.0 INTRODUCTION

The Geostationary Operational Satellite System Series R (GOES-R) is an operational mission to make observations from geostationary orbit. The GOES-R mission will provide an Advanced Baseline Imager (ABI), Hyperspectral Environmental Suite (HES), Space Environmental In-Situ Suite (SEISS), Solar Imaging Suite (SIS), Geostationary Lightning Mapper (GLM), and auxiliary communications services for the Data Collection System (DCS), Search and Rescue (SAR), and data relay functions that includes the GOES Rebroadcast (GRB) service, Low Rate Information Transmission (LRIT) service and the Emergency Managers Weather Information Network (EMWIN) service. The five GOES-R mission segments interface and function to support the total GOES-R mission and are listed below. The bold titles are items that are covered in this IRD.

- **Space Segment (SS)**
- Ground Located – Command, Control, and Communications Segment (GL-C3S)
- Product Generation and Distribution Segment (PGDS)
- User Interface Segment (UIS)
- Archive and Access Segment (AAS)

As part of the Space Segment (SS), the GOES-R will support the following services:

- GOES Rebroadcast Service (GRB)
- **Low Rate Information Transmission (LRIT) Service**
- Emergency Managers Weather Information Network (EMWIN) Service
- Data Collection System (DCS)
- Search and Rescue (SAR) Service

1.1 Purpose

The purpose of this document is to describe and specify the functional and performance interface requirements for the communication links between the GOES-R Space Segment (SS) and the Low Rate Information Transmission (LRIT) service.

This document it also intended to provide a basis for the subsequent development of a SS-LRIT Interface Control Document (ICD) by the spacecraft contractor.

1.2 Scope

The interfaces addressed in this document support the exchange of data between the SS and the LRIT ground segment.

The specifications for the SS functions will be contained in the Satellite Performance Specification. Only those parameters that are necessary to specify the interface requirements will be included here. This IRD therefore:

:

- Identifies required RF links between the SS and the LRIT ground segment
- Establishes functional and performance requirements related to these links

1.3 Document Overview

The following documents of the issue listed, or of the issue in effect on the effective date of contract, form a part of this IRD to the extent specified herein. In the event of conflict between documents specified herein and other detailed content of this IRD, this IRD shall be the superseding requirement.

[1] Mission Requirements Document 2B (MRD-2B) for the GOES-R Series, Version 2.2 dated March 17, 2005.

[2] NOAA/NESDIS Antennas and RF System Capabilities Handbook, NOAA/OSD3-2001-0043R0UD0, 10 August 2001

[3] MSG Ground Segment LRIT/HRIT Mission Specific Implementation, Document MSG/SPE/057, 9 March 2001

[4] CGMS LRIT/HRIT Global Specification, Document CGMS 03, Issue 2.6, 12 August 1999

[5] ITU Recommendation P.531-7 (2003), Ionospheric Propagation Data and Prediction Methods Required for the Design of Satellite Services and Systems

[6] ITU Recommendation P.581-2 (1990), The Concept of "Worst Month"

[7] ITU Recommendation P.618-8 (2003), Propagation Data and Prediction Methods Required for the Design of Earth-Space Telecommunication Systems

[8] ITU Recommendation P.676-5 (2001), Attenuation by Atmospheric Gases

[9] ITU Recommendation P.679-3 (2001), Propagation Data Required for the Design of Broadcasting-Satellite Systems

[10] ITU Recommendation P.837-4 (2003), Characteristics of Precipitation for Propagation Modeling

[11] ITU Recommendation P.838-2 (2003), Specific Attenuation Model for Rain for Use in Prediction Methods

[12] ITU Recommendation P.839-3 (2001), Rain Height Model for Prediction Methods

[13] ITU Recommendation P.841-3 (2003), Conversion of Annual Statistics to Worst-Month Statistics

[14] National Telecommunications and Information Administration "Manual of Regulations and Procedures for Federal Radio Frequency Management", May 2003 Edition, September 2004 Revision

[15] International Telecommunications Union (ITU) Recommendation ITU-R RA 769-1 of the 1998 Edition of the ITU Regulations for Radio Astronomy

[16] ITU Article S21 of the ITU Radio Regulations RR-S21 described in the 2001 Edition of the ITU Regulations for Power Flux Density

Discussion: References [3] and [4] are available on the Internet at the EUMETSAT website at http://www.eumetsat.de/

The ITU documents described in documents [5] thru [13] can be used in determining propagation attenuation. Document [5] is to be used for scintillation loss. The dash number used for each ITU document is the updated release number. The ITU web site for the documents is http://www.itu.int/publibase/catalog/index.asp

1.4 Missing Requirements

This document contains all LRIT RF interfaces except those labeled "TBD" and "TBR". "TBD (To Be Determined) means that the contractor should determine the missing requirement in coordination with the government. The term "TBR" (To Be Reviewed) implies that the requirement is subject to review for appropriateness by the contractor or the government.

1.5 Definitions

The statements in this document are not of equal importance. The word "shall" designates a requirement. Any deviations from requirements will need approval of the NASA contracting officer. The word "will" designates a statement of fact about the system, its operational environment or the intent of the government.

The word "threshold" is the minimum acceptable performance characteristic.

Rationale: MRD-2B, ID Item 1066

The word "goal" is an optimum level of performance, which, if met, could greatly enhance data utility.

Rationale: MRD-2B, ID Item 1067

2.0 LOW RATE INFORMATION TRANSMISSION (LRIT) SERVICE AND INTERFACE DESCRIPTION

The GOES support to the Low Rate Information Transmission (LRIT) service is provided by GOES satellites located at 75º and 137º [TBR] W. Longitude. This system provides unidirectional broadcast link connectivity between the originating uplink from the NOAA Command and Data Acquisition Stations (CDAS) and a large number of outlying LRIT terminals. These LRIT terminals are typically small receive-only stations. It is the intent of the GOES-R series satellite program to provide a continuation of the LRIT service that is provided on the GOES-N/O/P satellite program.

The SS satellite transponder that supports the LRIT service is bent-pipe, i.e., it receives the uplink signal within a certain frequency band, translates it to a new frequency band, amplifies it, and retransmits it on the downlink, but with no demodulation. For LRIT, the uplink is S-Band and the downlink is L-Band. The uplink coverage must include the CDAS, primary and backup; for simplicity and in accord with current GOES-N Series guidelines, this will be met utilizing an

earth coverage antenna. The downlink coverage must provide earth coverage out to a ground station elevation angle of 5º.

The LRIT transponder will support the transmission of low-resolution satellite imagery from the CDAS to a large number of small receiving sites.

3.0 LRIT RF INTERFACE REQUIREMENTS

3.1 General

The Low Rate Information Transmission (LRIT) is a unique digital data link that provides a service. The LRIT transponder supports the transmission of low-resolution satellite imagery from the CDAS to a large number of small receiving sites. This service is an evolution of the existing WEFAX analog facsimile transmission.

Rationale: MRD-2B, ID Item 4488

The LRIT service supports the widespread distribution of relatively low data rate low resolution satellite imagery from the CDAS to a large number of small receiving sites. Transmission is supported in the GOES-R satellite by a bent pipe transponder that must have the RF interface characteristics described in the following paragraphs.

Rationale: MRD-2B, ID Item 4489

The LRIT data link requirements summary is described in Table 3.1-1.

CDA Uplink Tx	**Requirement**	**Rationale**
EIRP (dBm)	[TBD]	
Frequency (MHz)	2028.400	MRD-2B, ID Item 4496
Polarization	Linear N-S	Heritage spec. from GOES-N,O,P
Polarization isolation (dB)	27 [TBR]	Comm. working group
Info. Data Rate (kbit/s)	256	ID item 4491 in MRD-2B
Tx Data Rate (kbit/s)	585	
Channel bandwidth (kHz)	600	ID item 4495 in MRD 2B
Format	NRZ-M	
Modulation	QPSK	Comm working group
FEC Code	Para. 3.2.2	
Satellite Rx		
Polarization	Linear N-S	
Polarization isolation (dB)	-27 [TBR]	
Antenna Coverage	Earth coverage to an antenna elevation angle of 5 degrees	MRD 2B ID 4498 [to be revised]
Min. Rx G/T (dB/K)	-14 at edge of coverage	
Dynamic Range	Nominal value ± 5 dB	Comm. working group
Satellite Tx		
Frequency (MHz)	1696.400 [TBR]	MRD-2B, ID Item 4497
Polarization	Linear N-S	

EIRP (dBm)	52.5 [TBR]	Comm. working group
Antenna Coverage	Earth coverage to an antenna elevation angle of 5 degrees	
BER	$1 \cdot 10^{-8}$ at 99.9 % availability worst cast (TBR)	ID 4494 in MRD-2B
Ground Rx		
Polarization	Linear N-S	
Min. Rx G/T (dB/K)	-0.3	Heritage spec. from GOES-N,O,P
Rx System Loss (dB)	1.0 [TBR]	

Table 3.1-1 LRIT Data Link Requirements Summary

3.2 CDAS Uplink Requirements

3.2.1 Uplink Filter Description

The LRIT uplink will use a square root raised cosine filter with excess bandwidth of 1.0.

Rationale: The goal is to be compatible with the EUMETSAT LRIT/HRIT specifications that are described in Appendix D of Meteosat Second Generation (MSG) Ground Segment LRIT/HRIT Mission Specific Implementation document MSG/SPE/057.

3.2.2 FEC Coding

Forward error correction coding will be a concatenated Convolutional Code, Rate-1/2 with constraint length 7, and a Reed-Solomon block code (255,223) with interleaving depth of 4.

Rationale: The LRIT coding will be the same as that used on the GOES-N,O,P Program.

3.2.3 Frequency Drift

The CDAS uplink frequency drift will be maintained at ≤ 1 part in 10^9.

3.2.4 Phase Noise

The uplink phase noise will meet the mask given in Figure 3.2.4-1.

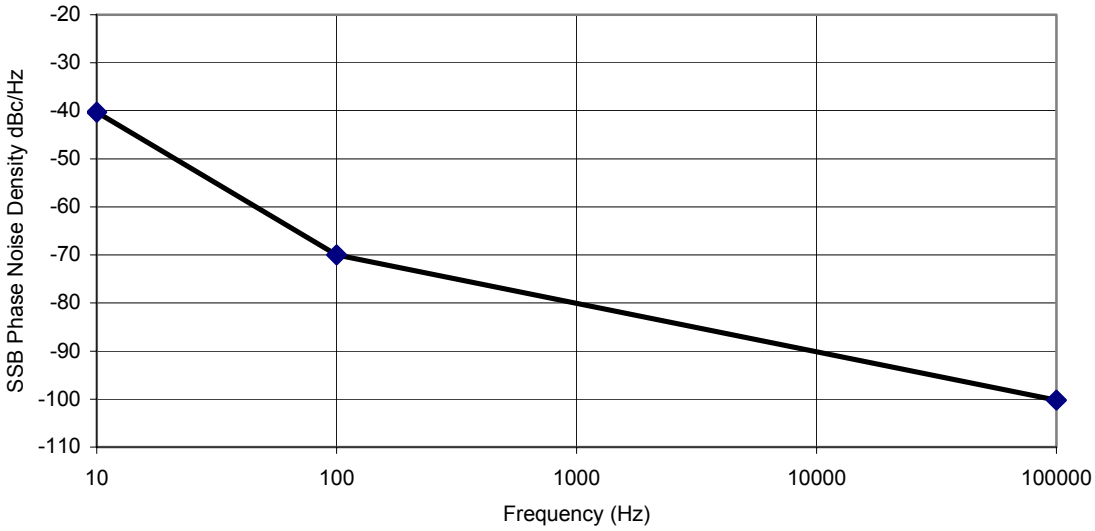

Figure 3.2.4-1 Phase Noise Specification

3.4 Satellite Downlink Interface Requirements

3.4.1 Eb/No Performance

The required E_b/N_0 is 5.1 dB [TBR] for the BER performance described in Table 3.1-1.

Rationale: This Eb/No value includes 2.3 dB [TBR] maximum degradation from theoretical performance for the concatenated Convolutional/Reed-Solomon code described in Section 3.2.2.

3.4.2 Satellite Phase Noise

The satellite transponder phase noise shall be below the mask given in Figure 3.2.4-1.

3.4.3 Unwanted Radiation Mask

All communication links must comply with paragraph 5.2.2 for frequencies less than 470 MHz and 5.6.2 for frequencies above 470 MHz, of the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management, May 2003 Edition, September 2004 Revision.

3.5 Ground Receive Interface Requirements

3.5.1 Frequency Tracking

The LRIT receiver will be capable of acquiring and tracking input signals within approximately ± 6 kHz [TBR] of the nominal receive frequency.

Rationale: Recommendation from Comm Working Group.

4.0 LINK PERFORMANCE REQUIREMENTS

4.1 General

The link performance shall meet the performance criteria described below. Performance is specified for the combined up and downlinks, i.e., for the full path between CDAS and the LRIT terminals.

4.1.1 Assumed Link Parameters

The following conditions shall be included in the calculation of expected link performance.

1. Propagation impairments are the rain and atmospheric attenuation loss of [TBD] on the uplink and the rain and atmospheric attenuation loss of [TBD] on the downlink The rain and atmospheric attenuation estimates shall be based on the ITU models for the CDAS and the back-up CDAS locations. The spacecraft contractor shall calculate the propagation impairments and present the data at the PDR. The data shall be incorporated into the ICD link budget following approval by GSFC.
2. Scintillation losses shall be the responsibility of the LRIT ground terminals and it is their responsibility to ensure link closure after accounting for scintillation losses at their location.

   Discussion: A reference document for ionospheric scintillation loss prediction is ITU-R Recommendation P.531-7.
3. A 0.25 dB [TBR] polarization loss shall be assumed for the uplink and a 0.25 dB [TBR] polarization loss shall be assumed for the downlink.
4. Interference: Co-channel and adjacent channel interference for the LRIT links shall be measured and included in the link budget calculations.
5. At the LRIT receiver, the required E_b/N_0 shall be as specified in Section 3.4.1.
6. The end-of-life link margin shall be 3 dB.

4.1.2 Link Availability

The link availability shall be 99.9 % for the worst month [TBR] under the assumptions of Section 4.1.1 and for a link BER requirement described in Table 3.1-1.

The link availability shall be shown by calculation using procedures outlined in the ITU documents [5] thru [13].

4.1.3 Radio Astronomy Band Protection

The EIRP values for the LRIT downlink shall protect the radio astronomy band from 1660 to 1670 MHz, so that the spectral power flux density in this band at the surface of the earth shall be $\leq$ -266 dB W/m^2-Hz.

Rationale: Compliance is required with the power flux density requirement for the Radio Astronomy Band as described in the international Telecommunications Union (ITU) Recommendation ITU-R RA 769-1. The ITU specifies a maximum PFD at the ground of -251

dBW/m^2 /Hz for the RA band, and this level must be reduced by another 15 dB for geostationary satellites.

4.1.4 Power Flux Density Limit

The EIRP for the LRIT downlink shall conform to the ITU regulations Section RRS21, Table S21-4 regarding Power Flux Density (PFD) at the surface of the Earth. The communications link shall comply for both the 1.5 MHz and 4 KHz bandwidth at L-Band.

The spacecraft contractor shall notify GSFC if he determines that any transmission channel requires a higher than allowed EIRP to meet the communications data link performance requirements.

The PFD values for each data transmission service shall be defined by the spacecraft contractor and incorporated into the Interface Control Document (ICD) following the Preliminary Design Review and after approval by GSFC.

Rationale: The ITU regulations are described in Article S21 titled "Terrestrial and space Services Sharing Frequency Bands above 1 GHz" of the ITU Radio Regulation RR-S21.

4.1.5 Communications Link Budget Requirement

The spacecraft contractor shall provide the link budgets for the LRIT service in the ICD at the Preliminary Design Review (PDR) following review and approval by GSFC.

Changes to the link budget shall be documented and reported monthly to the GSFC Communications Subsystem Manager.

Rationale: There is a need to ensure adequate link margins prior to freezing the design and proceeding with the manufacturing of flight hardware.

APPENDIX A – ABBREVIATIONS AND ACRONYMS

ALC	Automatic Level Control
AM	Amplitude Modulation
AS	Archive Segment
β	Modulation Index
BCH	Bose-Chaudhuri-Hocquenghem (Forward Error Correction Code)
BER	Bit Error Rate
BiΦ-L	Bi-Phase Level
BPSK	Binary Phase Shift Keying
BW	Bandwidth or Beamwidth (context dependent)
C3S	Command, Control and Communications Segment
CCSDS	Consultative Committee on Space Data Systems
CDA(S)	Command and Data Acquisition (Station)
CGMS	Coordination Group for Meteorological Satellites
C/N_0	Carrier to Noise Density Ratio (dB-Hz)

COSPAS	(Russian: Cosmicheskaya Sistyema Poiska Avariynich Sudov) Space System for the Search of Vessels in Distress
CP	Circularly Polarized or Circular Polarization
CWG	Communications Working Group
DCP	Data Collection Platform
DCPI	Data Collection Platform Interrogate
DCPR	Data Collection Platform Report
DCS	Data Collection System
DRGS	Direct Readout Ground Station
EIRP	Effective Isotropically Radiated Power
ELT	Emergency Locator Transmitter
EMWIN	Emergency Managers Weather Information Network
EPIRB	Emergency Position Indicating Radio Beacons
FEC	Forward Error Correction
GEOLUT	Geostationary Local User Terminal
GOES	Geostationary Operational Environmental Satellite
GRB	GOES Rebroadcast
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
G/T	Gain-to-Noise Temperature Ratio (dB/K)
HRIT	High Rate Image Transmission
ICD	Interface Control Document
IESS	Intelsat Earth Station Standards
IRD	Interface Requirements Document
ITU	International Telecommunications Union
L-Band	1.0 – 2.0 GHz Frequency Band
LDPC	Low Density Parity Check Code
LEO	Low Earth Orbit
LHCP	Left Hand Circularly Polarized
LP	Linearly Polarized or Linear Polarization
LRIT	Low Rate Information Transmission
LSS	Launch Support Segment
LUT	Local User Terminal
MCC	Cospas-Sarsat Mission Control Center
MSG	Meteosat Second Generation
NASA	National Aeronautics and Space Administration
NOAA	National Oceanographic and Atmospheric Administration

OQPSK	Offset Quadra-phase Shift Key
PDR	Preliminary Design Review
PFD	Power Flux Density
PGDS	Product Generation and Distribution Segment
PLB	Personal Locator Beacon
PM	Phase Modulation
ppm	Parts per million
PSK	Phase Shift Keying
QPSK	Quadra-phase Shift Key
RA	Radio Astronomy
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
RMS	Root Mean Square
RR	Radio Regulations
SAR	Search and Rescue
SARSAT	Search and Rescue Satellite-Aided Tracking
S-Band	2.0-- 4.0 GHz Frequency Band
SEISS	Space Environment In-Situ Suite
SS	Space Segment
TBD	To Be Determined
TBR	To Be Reviewed
TBS	To Be Supplied
UHF	300 – 1000 MHz Frequency Band
UIS	User Interface Segment
USG	United States Government
X-Band	8.0 – 12.0 GHZ Frequency Band